THE MERGING SYSTEM AM 2049-691

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ABSTRACT

Spectroscopic and photometric observations of the pair of comparable sized interacting galaxies, AM 2049-691, are presented here. The systemic velocity is V_{GSR} = (10956 ± 30) km s^{-1}, and the derived distance (H_0 = 75 km s^{-1} Mpc^{-1}) results 146 Mpc. A bridge is observed between the very distinct nuclei whose separation is about 10 kpc, as well as two tails that emerge from the extremes SW and NE of the main body and extend in opposite directions up to 41 and 58 kpc respectively. The spectral characteristics of the all observed zones are typical of H II regions of low excitation. The internal reddening is quit high, particularly in the NE nucleus. The N(O)/N(H) ratio reveals a comparative overabundance of nitrogen with respect to the oxygen in the SW nucleus; thus in this double system the overabundance of N is detected in only one component. All the derived equivalent widths of the Hα + [N II] lines indicate enhanced star formation compared with isolated galaxies, especially in the NE nucleus; the equivalent width corresponding to the integrated spectrum reflects a global starbust activity in the whole object, and is compatible with a merger of two disk galaxies. In the two nuclei of AM 2049-691 the derived oxygen and nitrogen abundances, the N(O)/N(H) ratios, electron temperatures and densities, internal reddenings, and equivalent widths are different, which suggest that these nuclei have had different evolutions. In this system, in spite of the interaction between members, there is not high IR emission detected nor a starburst type nucleus in neither of the two components as observed in other cases. The integrated total color B – V corresponds to a Sc-Scd galaxy and its average population would be of F7-F8 type. Indicative B – V colors of the nuclei, corrected for internal absorption, suggest they are star forming regions, being the star formation activity more intense in the NE nucleus as found from the spectroscopic data. The central radial velocity dispersions at each nucleus indicate that the most massive galaxy would be the progenitor of the SW component. The observed radial velocity curve shows the presence of two subsystems, each one associated to a different nucleus.

Key words: galaxies: individual (AM 2049-691) --- galaxies: peculiar --- galaxies: nuclei --- techniques: spectroscopic --- techniques: photometric

1. INTRODUCTION

The observation of the main characteristics of objects with double nucleus and/or distorted morphology indicative of evident gravitational interactions or mergers, allows to improve the knowledge about their natures and the involved physical processes. Their study makes possible to better understand the connections between interactions and different properties such as the separation and size of the components, velocity differences, global or individual star formation activity, infrared emission, etc.

In an attempt to contribute to the understanding of this kind of objects we present here spectroscopic and photometric observations of AM 2049-691 (ESO 074-IG 020, IRAS 20494-6913). This object is an interacting double system composed of a pair of galaxies of comparable sizes, whose morphological types would be Sb-c and Sb (Lauberts and Valentijn 1989). It presents the general appearance of a double nucleus system (Fig. 1). A bridge is observed between the very distinct nuclei, whose separation is about 14", corresponding to a distance of 10 kpc (H_0 = 75 km s^{-1} Mpc^{-1}). The object shows two tails that extend in opposite directions; the tail that emerges from the SW extreme of the central body (0'.6 x 0'.2) is clearly visible up to ~ 41 kpc from its center, whereas the other one reaches a distance of 58 kpc. At the tip of this last tidal tail it is seen what seems to be a dwarf galaxy as it was observed out of the debris of merging disk galaxies (Mirabel et al. 1992).

We have analyzed the main spectral characteristics of AM 2049-691, determined the principal excitation mechanisms, the physical conditions, abundances and radial velocities of the most important features as well as its B magnitude and B – V, V – R, and R – I color indexes.

2. OBSERVATIONS AND REDUCTIONS

2. 1. Spectra

Spectroscopic observations of AM 2049-691 were carried out on 1999 June 15 and 16 with the REOSC spectrograph coupled to the 2.15 m Ritchey-Chrétien telescope of The Complejo Astronómico El Leoncito, San Juan, Argentina, using a Tektronix 1024 x 1024 pixels CCD. The seeing was between 2'' and 3'' (FWHM). Two set of spectra were obtained through a slit of ~ 2'' wide and ~ 3' long, along P.A. = 30º. One of them was taken using a 1200 lines mm^{-1} grating over a wavelength range of ~ 6400-7000 Å, and the other one with a 300 lines mm^{-1} grating covering the wavelength range of ~ 3800-7200 Å. The dispersions were 32 and 129 Å mm^{-1} and the resolutions 2.5 and 10 Å, respectively. The spectra were corrected for atmospheric and Galactic extinction (A_B = 0.15; Burstein & Heiles 1984), and flux calibrated with stars from the catalogue of Stone and Baldwin (1982).

2. 2. CCD Photometry

Broadband B, V, R, and I photometric observations were performed on 1999 July 6, 7, and 8 with the CASLEO telescope and the CCD described above. The scale was 0''.27 $pixel^{-1}$. The seeing during observations was also 2''-3'' (FWHM). The obtained data were corrected for atmospheric extinction but they were not corrected for Galactic extinction. The photometric calibration was made using standard stars from Graham (1982) observed through the same filters.

Data reduction of spectra and images was accomplished using the standard methods in IRAF (developed by NOAO) reduction package. The journal of observations of AM 2049-691 is presented in Table 1.

3. SPECTROSCOPY

In the spectra of the seven regions listed in Table 2 (regions 3 and 6 correspond to the centers of the NE and SW nuclear regions, respectively), obtained using the 300 lines mm^{-1} grating, the lines measured were [O II] λ 3727, Hβ, [O III] λ 5007, [O I] λ 6300, Hα, [N II] $\lambda\lambda$ 6548, 6584, and [S II] $\lambda\lambda$ 6717, 6731. In all tables and figures the distances are given with respect to region 3, being positive toward the NE. The intensities were derived by fitting Gaussians to their profiles. The intensities of the [O III] λ 4959 lines were constrained to the theoretical ratio [O III] λ 4959 = 1/3 [O III] λ 5007, so this line is not listed in Table 2. The internal reddening correction was applied using the interstellar extinction curves given by Seaton (1979), assuming that the optical properties of the dust in AM 2049-691 are similar to those of the dust in the Galaxy. Intrinsic ratios Hα/Hβ = 2.85 (Osterbrock 1989) were adopted to derive the values of c, the logarithmic extinction at Hβ.

For the mentioned seven regions the measured and corrected line intensities F_λ and I_λ, relative to Hβ = 1.00, as well as the errors which were estimated from the noise level around each line, are listed in Table 2. The values of c and the corrected Hβ fluxes are given at the bottom of this table. The spectra of all these regions present strong emission lines in the red zones

(Fig. 2); their characteristics are typical of H II regions of low excitation, being the excitation considerably lower in region 3 than in region 6 (Fig. 3). The principal excitation mechanisms would be photoionization by young massive stars. The internal reddening is quite high, especially in region 3; a general decreasing trend is observed from NE to SW 8 (Fig. 4).

3.1. Abundances, physical conditions and equivalent widths

The abundance ratios N(O)/N(H) and N(N)/N(H), the electron temperatures T_e and densities N_e were obtained for regions 1 to 7. For the N(O)/N(H) abundances, the average values of N(O)/NH(H) derived from the empirical calibrations of Edmunds and Pagel (1984) were adopted. Assuming

$$N(O)/N(H) \approx N(O^+) + N(O^{++})/N(H^+) \tag{1}$$

and $N(N)/N(O) \approx N(N^+)/N(O^+)$, the nitrogen abundance is $N(N)/N(H) \approx N(O^+) + N(O^{++})/ N(O^+) \times N(N^+)/N(H^+)$. Expressions given by Díaz (1985) were used for the involved ionic abundances. The electron temperatures were obtained from equation (1) by searching the required values of T_e for the previously adopted N(O)/N(H) abundances; the electron densities were derived from the [S II] λ6717/λ6731 ratios (Osterbrock 1989). The results are presented in Table 3. The electron temperatures are rather low, but they are in the range of normal values for H II regions; electron densities are also within that range.

The derived nitrogen (Fig. 5a) and oxygen (Fig. 5b) abundances present two maxima corresponding to the region 3 (NE nucleus) and region 6 (SW nucleus), being the abundances of both elements higher in the NE nucleus than in the SW one. In region 3 the N(O)/N(H) and N(N)/N(H) abundance ratios are

2.0 and 1.2 times of the corresponding solar abundances. In region 6 both N(O)/N(H) and N(N)/N(H) ratios are about 1.1 of the respective solar values. The N(N)/N(O) ratios (Fig. 6) in the region 3 and towards the NE, are practically coincident with those of the galactic emission regions (Shaver et al. 1983), indicating the same proportions of the involved elements. Towards the SW these ratios increase, being in region 6 very close to the corresponding solar value and about twice of those of galactic regions; this indicates a comparative overabundance of N with respect to the O, which is reflected in the relatively high [N II] λ6584/Hα ratios.

AM 2049-691 is a double system where the overabundance of nitrogen is observed in only one component. Overabundance of N was also detected in the Seyfert component of the interacting pair of galaxies NGC 5953 (Seyfert nucleus) and NGC 5954 (LINER) (González Delgado & Pérez 1996).

The equivalent widths EW(Hα + [N II]) also show two maxima (Fig. 7) at the two nuclei, being EW(Hα + [N II]) = 67 Å and 48 Å for the NE and SW nuclei respectively. All the obtained values indicate enhanced star formation activity compared with isolated galaxies, especially in the NE nucleus. The equivalent width EW(Hα + [N II]) = 58 Å derived from the integrated spectrum of AM 2049-691 reflects a global star formation activity, which could be favored with the usually large amounts of gas that spiral galaxies have, and is compatible with a merger of two disk galaxies (Liu & Kennicutt 1995). This system is composed of an interacting pair of galaxies of comparable sizes and similar morphological types where the star formation activity, presumably induced by interaction, takes place in both nuclei being more significant in the north-eastern one, as detected in some other pairs (Sekiguchi & Wolstencroft 1992), and in the whole object. This differs from the results of Joseph et al. (1984) who found evidence of this activity in only one member of their observed pairs; Agüero et al. (2000) studied a double nucleus system and they did not observe important star formation outside of the nuclei, being one of them a starburst nucleus type. It is interesting to notice that the star formation efficiency seems not correlate with the pair separations (Combes et al. 1994).

The Hα equivalent widths determined for the NE and SW nuclei are EW(Hα) = 44 and 25 Å; the bursts of star formation in their interiors have indicative ages of 8.5×10^6 and 9×10^6 yr according to the standard model for an instantaneous burst with metallicities of 1.5 $Z_{\odot}$ (value interpolated between the two curves corresponding to 1 and 2 $Z_{\odot}$; Leitherer and Heckman 1995) and 1 $Z_{\odot}$.

AM 2049-691 is a pair of comparably sized interacting galaxies of very close morphological types with a separation comparable to their sizes as it was before mentioned. Nevertheless the O and N abundances, N(N)/N(O) ratios, electron temperatures and densities, internal reddenings, and equivalent widths are different in the NE and SW nuclei, which suggest that, in spite of their similarities, the two components have undergone different evolutions. It is possible that the members had similar initial conditions, but it is also possible that the gas transfer between them during interaction had fueled principally one of the nuclei.

3. 2. Radial Velocities

Radial velocities were derived from the spectrum obtained with the 1200 lines mm^{-1} grating by measuring the centroids of Gaussian curves fitted at the profiles of the strongest emission lines. The resulting heliocentric radial velocities of NE and SW nuclei are V_{NE} = (10977 ± 18) km s^{-1} and V_{SW} = (11144 ± 13) km s^{-1} respectively, which are consistent with those of Sekiguchi & Wolstencroft (1992). The average velocity was adopted as the systemic velocity of AM 2049-691, which referred to the Galactic System of Rest is V_{GSR} = (10956 ± 30) km s^{-1}, and the derived distance (H_0 = 75 km s^{-1} Mpc^{-1}) results 146 Mpc.

Slight asymmetries were detected in the nuclear emission lines and they can be fitted by secondary components, 100 km/s blueward at SW nucleus and 150 km/s redward at NE nucleus.

The Na I (λ5892.9 Å) absorption line was also detected in the continuum emission of each nuclei, with velocities V_{NE} = (10977 ± 20) km s^{-1} and V_{SW} = (11140 ± 20) km s^{-1}. This absorption line appeared with almost the same equivalent width (~ 2 Å) at both nuclei but the FWHM of each line were different. Their measured radial velocity dispersions were σ_{NE} = (280 ± 20) km s^{-1} and σ_{SW} = (330 ± 20) km s^{-1} and the deconvolved central radial velocity dispersion of the stellar systems are σ_{NE} = (225 ± 20) km s^{-1} and σ_{SW} = (280 ± 20) km s^{-1}. As the nuclear dynamics of ellipticals and normal bulges in spirals has been found to be indistinguishable (Kormendy and Illingworth 1982) we can consider, at first approximation, the central velocity dispersions as indicative of the relative masses of the original systems, thus the the progenitor galaxy of the SW component would be the most massive of the pair. The stellar radial velocity dispersion allows us to estimate the mass and tidal radius (e.g. Bowers & Deeming 1984) of each nuclear-bulge component, which turns out to be roughly 5.9 x 10^{10} $M_{\odot}$ and 6.1 kpc for NE nucleus; and 9.4 x 10^{10} $M_{\odot}$ and 8.4

kpc for SW nucleus.

Following the results of Kormendy and Illingworth (1983) about the $L \propto \sigma^n$ relation for disk-galaxy bulges, the values presented here are roughly consistent with the progenitor systems being spiral galaxies with M_B ~ -21. These values are in accordance with the global photometric properties presented in section 4.2 and the spectrophotometric results discussed in section 3.1.

The emission lines velocity distribution (along P.A. = 30º) is illustrated in Figure 8a, where the open circles correspond to the two distinct nuclei. The radial velocity curve along the line joining both nuclei shows the presence of two different components separated by a velocity discontinuity of ~100 km s^{-1}, and a first glance of the curve suggests that each one is associated with a different nucleus. The NE component has an approximate solid body (SB) behavior at all the measured positions and the SW component appears to have a strong asymmetry in the velocity values respect to the nucleus. However, a close inspection of the spectra showed us that the Hα emission has a minimum between both nuclei at 1/2 of the distance from NE to SW nucleus, then the three points after the velocity discontinuity, have photometrical continuity with the NE emission complex, as shown in Figure 8b. As the tidal radius of NE system is smaller (r_T ~ 6 kpc), this feature could be caused by tidal disruption of the NE gaseous system, part of which could have became gravitationally bounded to the SW body, apparently the most massive one. This peculiar kinematic feature and the strong Hα emission makes this merging galaxy an ideal target for two-dimensional spectroscopy.

The global appearance of the rotation curve is solid body (SB) like at 70% of the observed positions. SB rotation curves appear more frequently in low luminosity galaxies and in interacting disk galaxies (Keel 1996). In the case of AM 2049-691 the SB appearance would not necessary correspond to a spherical halo mass distribution, since recent numerical simulations have shown that an appropriate combination of perturbation and dust obscuration in the disk can explain the SB appearance of an interacting galaxy rotation curve at a wide range of radii (Díaz et al. 2000).

As a whole system, AM 2049-691 shows a velocity amplitude of ~ 330 km s^{-1} (sin i) $^{-1}$ within a diameter of ~ 23 kpc and the kinematical center is possibly located on the line joining both nuclei. The total keplerian mass inside a radius of 11.5 kpc is ~ 1.4 x 10^{11} $M_{\odot}$; as the orientation is unknown and this system is far from relaxation, this is only a very rough estimate, but consistent with the luminosities reported in the next section.

4. PHOTOMETRY

4. 1. Infrared Data

AM 2049-591 is not a luminous infrared object ($L_{FIR} < 10^{11}$ L) but it has an appreciable IR emission. Its far infrared flux, FIR = 1.26 x $10^{-11}(2.58S_{60} + S_{100})$ (Londsdale & et al. 1985) = 7.4 x 10^{-11} erg cm^{-2} s^{-1}, calculated using the appropriated data from the IRAS Point Source Catalog (1988) leads, adopting a mean distance of 146 Mpc (H_0 = 75 km s^{-1} Mpc^{-1}), to the IR luminosity L_{FIR} = 5 x 10^{10} $L_{\odot}$, which is compatible with a merger system. Its comparatively low infrared colors $\alpha(60, 25) = -2.5$ and $\alpha(100, 60) = -1.5$ indicate it is a nonactive object.

In this system, the interaction seems not to have produced very high IR emission nor a starburst type nucleus in neither of the two components such as in other cases (e. g. Agüero et al. 2000; Diaz et al. 2000).

4. 2. Magnitudes and Colors

B magnitudes and B – V, V – R, and R – I colors of AM 2049-691 were derived using circular apertures with increasing radii (after removing the stars) centered on a point equidistant from the two nuclei. The photometric useful frames were smaller than the total estimated galaxy size, so asymptotical extrapolations of the obtained values were used to estimate the total magnitudes. The obtained results are B = 14.40, B – V = 0.52, V – R = 0.47, and R - I = 0.59. The uncertainties are 0.02 in B, 0.05 in B – V, and 0.06 in V – R and R – I. The magnitudes B and R obtained here are coherent with those of Lauberts and Valentijn (1989), considering as the total magnitude of the whole system that derived from the sum of their individual values for the NE and SW components. The integrated total color B – V would correspond to a Sc-Scd galaxy (Roberts & Heines 1994) and indicates that the integrated population would be between the F7 and F8 types.

Although both nuclei are probably contaminating each other, their magnitudes and colors were derived to be considered in an indicative way. Diaphragms with radii of 5" were used for both nuclei. The B magnitudes and B – V colors corresponding to the northeastern and southwestern nuclei are 16.28 and 16.66, and 0.75 and 0.87 respectively. After correcting these values for internal absorption by adopting $A_\lambda = E_{B-V}$. X(x) and the extinction curves given by Seaton (1979), the B – V colors for the NE and SW nuclei became – 0.25

and 0.19, corresponding respectively to average integrated populations of B1-B2 and A6-A7 types, which are consistent with the previously estimated ages.

These values clearly indicate that the two nuclei are star forming regions, being the star formation activity more intense in the northeastern nucleus than in the other one, as found from the spectroscopical data.

5. SUMMARY

We performed CCD spectroscopic and broadband B, V, R, and I photometric observations of AM 2049-691 that is a pair of comparably sized interacting galaxies of morphological types Sa-Sb and Sb-Sc with a separation comparable to their sizes. From the derived information the principal results are:

The spectral characteristics of the all studied regions are typical of H II regions of low excitation; their dominant excitation mechanisms would be the photoionization by young massive stars. The internal reddening is quite high, especially in the northeastern nucleus, and reveals an inhomogeneous obscuration.

The N(N)/N(O) ratio suggests in that nucleus and towards the NE the same proportion of oxygen and nitrogen as in galactic emission regions. This ratio increases towards the SW being in the southwestern nucleus about twice of those in the mentioned regions indicating there a comparative overabundance of N with respect to O, which is reflected in the relatively high [N II] λ6584/Hα ratios. Then in this double system the overabundance of nitrogen is detected in only one component.

All the derived equivalent widths of the Hα + [N II] lines indicate enhanced star formation activity compared with isolated galaxies, being this activity more intense in the NE nucleus; the equivalent width corresponding to the integrated spectrum suggests a global starburst activity in the whole object and is compatible with a merger of two disk galaxies.

In the two nuclei of AM 2049-691 the derived oxygen and nitrogen abundances, the N(O)/N(H) ratios, electron temperatures and densities, internal reddenings, and equivalent widths are different, which suggests that these nuclei have had different evolutions.

AM 2049-691 is not a luminous infrared system but has an appreciable IR emission: $L_{FIR} = 5 \times 10^{10}\ L_{\odot}$; its comparatively low far infrared colors $\alpha(60,25)$ and $\alpha(100,60)$ indicate it as a nonactive object.

In this system, in spite of the interaction between members, there is not high IR emission detected nor a starburst type nucleus in neither of the two components as it is observed in other cases.

The integrated total color B – V corresponds to a Sc-Scd galaxy and its average integrated population would be between F7 and F8 types. Indicative B – V colors of the nuclei, after correcting for internal extinction, suggest they are star forming regions, being the star forming activity more intense in the NE nucleus in agreement with the estimated ages, as found from the spectroscopical data.

The central radial velocity dispersion at each nucleus indicate that the most massive galaxy was the progenitor of the SW component. The observed radial velocity curve shows the presence of two components (each one associated to a different nucleus) that undoubtedly correspond to the merging galaxies, which is confirmed by the distinct spectrophotometric and photometric properties shown by the structures associated to each nuclei.

AM 2049-691 is an ongoing merger with moderate to low star formation activity with respect to other mergers at the similar evolutionary stage. It has a high level of disruption and interpenetration, but still shows a double set of morphologycal, spectrophotometrical and kinematical subsystems.

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FIGURE CAPTIONS

Fig. 1. Blue image (from ESO plates) of AM 2049-691. North is at the top and east to the left. The lines mark P.A. = 30º.

Fig. 2. Spectrum of: (a) region 3 (NE nucleus), (b) region 6 (SW nucleus). Dispersion is 129 Å mm^{-1}.

Fig. 3. Excitation vs. distance. Empty circles correspond to the centers of the northeastern and southwestern nuclear regions. Distances are given with respect to region 3, being positive to the northeast.

Fig. 4. Internal reddening vs. distance. Symbols and distances are as in Fig. 3.

Fig. 5. Abundances vs. distance: (a) N(N)/N(H), (b) N(O)/N(H). Symbols and distances are as in Fig. 3.

Fig. 6. N(N)/N(O) ratios vs. distance. Symbols and distances are as in Fig. 3.

Fig. 7. Equivalent widths vs. distance. Symbols and distances are as in Fig. 3.

Fig. 8. (a) Radial velocity distribution along P.A. = 30º. The values correspond to the weighted average velocities from the Hα, [N II] λλ 6548, 6584 lines. Bars indicate errors. Symbols and distances are as in Fig. 3.

(b) Hα emission profile along P.A. = 30º.

TABLE 1
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Date	Spectral Region or Filter	Exposure Time (s)	Comments
1999 June 15	λλ6400-7000	1200	P.A.=30°
1999 June 15	λλ6400-7000	1200	P.A.=30°
1999 June 16	λλ3800-7200	1800	P.A.=30°
1999 June 16	λλ3800-7200	1800	P.A.=30°
1999 July 6	B	30	
1999 July 6	B	30	
1999 July 6	B	300	
1999 July 6	B	300	
1999 July 6	B	300	
1999 July 6	V	30	
1999 July 6	V	30	
1999 July 6	V	300	
1999 July 6	V	300	
1999 July 7	R	60	
1999 July 7	R	60	
1999 July 7	I	60	
1999 July 7	I	60	

TABLE 2
LINE INTENSITIES RELATIVE TO Hβ

Ion	λ (Å)	Fλ/Fβ Iλ/Iβ σ						
		Region 1 5".1	Region 2 2".0	Region 3 0"	Region 4 -2".0	Region 5 -12".2	Region 6 -14".2	Region 7 -16".3
[O III]	3727	1.18	0.89	0.60	0.76	1.63	1.10	1.17
		3.11	2.10	1.61	1.72	3.12	2.16	2.33
		0.02	0.01	0.005	0.01	0.09	0.06	0.06
Hβ	4861	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00	1.00	1.00
		-	-	-	-	-	-	-
[O III]	5007	0.60	0.29	0.21	0.56	0.60	0.74	0.88
		0.52	0.26	0.18	0.50	0.55	0.68	0.80
		0.01	0.01	0.001	0.01	0.01	0.01	0.02
[O I]	6300	0.31	0.26	0.19	0.24	0.12	0.17	0.38
		0.11	0.10	0.06	0.10	0.06	0.08	0.18
		0.01	0.01	0.001	0.01	0.01	0.01	0.01
[N II]	6548	1.31	1.10	1.24	1.59	1.40	2.08	2.39
		0.39	0.37	0.36	0.57	0.62	0.90	1.00
		0.01	0.01	0.005	0.01	0.03	0.04	0.04
Hα	6563	9.67	8.45	9.84	8.04	6.50	6.67	6.80
		2.85	2.85	2.85	2.85	2.85	2.85	2.85
		0.08	0.06	0.04	0.07	0.12	0.12	0.12
[N II]	6584	3.82	3.41	3.90	3.54	3.51	4.00	3.76
		1.11	1.14	1.12	1.24	1.52	1.70	1.56
		0.03	0.03	0.01	0.03	0.07	0.07	0.06
[S II]	6717	1.37	0.89	0.94	0.94	1.49	1.69	1.36
		0.37	0.28	0.25	0.31	0.62	0.68	0.54
		0.01	0.01	0.003	0.01	0.03	0.03	0.03
[S II]	6731	0.92	0.73	0.84	0.91	1.18	1.08	1.09
		0.25	0.23	0.22	0.30	0.49	0.44	0.43
		0.01	0.01	0.003	0.01	0.02	0.02	0.02
c		1.58	1.40	1.60	1.33	1.05	1.08	1.11
log Iβ		-13.27	-12.98	-12.75	-13.04	-13.50	-13.42	-13.48

Note - Iβ is the reddening corrected flux in erg cm^{-2} s^{-1}, and σ is the absolute error of the Fλ/Fβ ratio. Example: Region 3, $F_{H\alpha}/F\beta = 9.84 \pm 0.04$

TABLE 3
RELATIVE ABUNDANCES AND PHYSICAL CONDITIONS

Parameter	Region 1 5''.1	Region 2 2''.0	Region 3 0''	Region 4 -2''.0	Region 5 -12''.2	Region 6 -14''.2	Region 7 -16''.3
N(O)/N(H) x 10^4	7.2	11.6	14.6	9.1	7.6	7.7	6.6
N(N)/N(H) x 10^5	4.9	8.3	10.9	9.1	7.0	9.9	8.1
N(N)/N(O)	0.07	0.07	0.07	0.10	0.09	0.13	0.12
T_e (K)	7080	6140	5720	6250	7030	6670	6940
N_e (cm^{-3})	10	160	270	400	140	10	140